REPORT OF THE CHIEF OF THE BUREAU OF AGRICULTURAL AND INDUSTRIAL CHEMISTRY, AGRICULTURAL RESEARCH ADMINISTRATION, 1944

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 29, 1944.

DR. E. C. AUCHTER,
Administrator of Agricultural Research.

DEAR DR. AUCHTER: I present herewith the report of the Bureau of Agricultural and Industrial Chemistry for the fiscal year ended June 30, 1944.

Sincerely,
ORVILLE E. MAY, *Chief.*

INTRODUCTION

The Bureau of Agricultural and Industrial Chemistry attempts through research to benefit agriculture and at the same time to make major contributions to the welfare of the Nation as a whole. To achieve this goal the Bureau develops both food and nonfood uses for agricultural commodities and wastes by the application of chemistry and allied sciences. Established industrial uses of inedible products receive attention because it may be desirable to better adapt the products to these uses. New uses of primary or derived products are sought to provide adequate consuming markets. In cases where domestic agricultural products are lacking, or insufficient, or unsuitable for particular industrial uses, efforts are made to find domestic products that can serve directly, or be adapted to serve, the special purposes.

During the past year, as during 1943 and part of 1942, the work of the Bureau was concentrated on particular phases of its authorized fields of reseach that promised to yield information of value in furthering the Nation's war effort. Some of the work was suggested by and conducted in collaboration with the War or Navy Department or special war agencies. However, some time and thought were given by the administrative officers and division heads to the revision of current projects and preparation of new research line projects that can be put in effect promptly when it is possible again to emphasize peacetime objectives in the research program of the Department.

This Bureau collaborated with other units of the Department and with State agricultural agencies by preparing reports on the industrial alcohol and food processing industries to aid in post-war planning. As usual, conferences were held with representatives of the State agricultural experiment stations to consider the programs of the Bureau's four regional research laboratories.

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In addition to the brief statements in this report on some of the important results of research during the past year, more detailed information on these and other research activities of the Bureau may be found in the 268 publications issued by it during the year and in the specifications of the 10 patents granted to employees. A list of publications and patents is available in mimeographed form.

The two most important industrial developments during the past year that resulted in large measure from the research work of this Bureau were the phenomenal growth of penicillin manufacture and the definite establishment of the sweetpotato starch industry by the construction of a privately owned and financed plant to process about 150 tons of sweetpotatoes per day. Although not yet in commercial use, the processes for making butadiene, the most important intermediate for synthetic rubber, from butylene glycol and for making the latter by fermentation of grain have been brought through laboratory and pilot-plant experiments to the stage where they can be applied commercially.

The research on food dehydration resulted in the publication of a manual for plant operators containing explicit instructions for dehydrating particular vegetables and fruits.

For the first time, the possibility of complete factory conversion of raw starch to sugars by mixed enzymes, as occurs in the digestive tracts of some animals, was demonstrated. An improved process for separating starch from wheat flour and recovering the protein unchanged in physical and chemical properties was developed. A new polymerizable starch derivative, allyl starch, which before polymerization is insoluble in water but soluble in organic solvents, was prepared and shown to be useful for protective coatings and laminated plastics.

Adhesives were made from peanut protein and found to be useful without heat for gumming paper, for bookbinding, and for making paper boxes. A waterproof glue for plywood was made from soybean meal and phenolic resin.

Fractions of ground corncobs and other crop residues were proven to be among the best materials available for use as soft grit in cleaning airplane engines and other fine machine parts by air blast.

New oil-soluble and water-insoluble nicotine compounds, some having fungicidal properties, were developed for insecticidal use.

A new process of recovering tartaric acid and tartrates for food and industrial uses from the wastes of the domestic wine and brandy industries was proven to be commercially feasible.

Sweetpotato vines preserved as silage were found to be equal to corn silage in feeding value and eminently suitable for winter feeding of dairy cattle in the South.

Cotton tire cords were greatly improved in physical properties by a "dual-stretch" process developed at the Southern Regional Research Laboratory.

Sixty-five applications for patents were filed in the Patent Office and information for use in preparing 108 additional applications was sent to the Office of the Solicitor. Ten patents were granted during the year and action on 147 patent applications was still pending on June 30, 1944.

The Nicholas Appert medal for outstanding work in food technology was awarded on May 30 to Dr. C. A. Browne, formerly Chief of the

Bureau of Chemistry, and since his retirement from the position of Supervisor of Chemical Research in 1940 an unpaid collaborator in this Bureau.

Dr. William W. Skinner, who became Chief of the Bureau in November 1942 following the death of Dr. Henry G. Knight and who had previously been Assistant and Associate Chief of the Bureau for many years, retired on March 31, being succeeded by the present Chief. Edward M. Chace, who had been in charge of the Bureau's Fruit and Vegetable Chemistry Laboratory at Los Angeles for 32 years, retired on June 30. Charles A. Wolfe, formerly head of the Division of Administrative Services, retired from his position as administrative officer on December 31, 1943, because of disability. Up to the end of the fiscal year, 220 persons, about one-third of whom were professional employees, had been furloughed for military service. The total number of full-time employees on the pay roll of the Bureau on June 30, 1944, was 1,246, of whom 603 were professional employees. The administrative officers of the Bureau and heads of its research laboratories and divisions, as of June 30, 1944, are listed below.

BUREAU ORGANIZATION AT END OF FISCAL YEAR 1944

Chief of Bureau	Orville E. May.
Assistant Chief	Carl F. Speh.
Assistant Chief	Henry A. Donovan.
Agricultural Chemical Research Division	Harlow H. Hall, Acting Chief.
Allergens Research Division	Henry Stevens, Chief.
Enzyme and Phytochemistry Research Division	Arnold K. Balls, Chief.
Pharmacological Research Division	Floyd DeEds, Chief.
Microbiology Research Division	Vernon H. McFarlane, Acting Chief.
Naval Stores Research Division	Leo A. Goldblatt, Acting Chief.

NORTHERN REGIONAL RESEARCH LABORATORY, PEORIA, ILL.

Director	Horace T. Herrick.
Agricultural Motor Fuels Division	Cecil T. Langford, Acting Chief.
Agricultural Residues Division	Elbert C. Lathrop, Chief.
Analytical and Physical Chemical Division	Reid T. Milner, Chief.
Commodity Development Division	P. Burke Jacobs, Acting Chief.
Engineering and Development Division	Cecil T. Langford, Chief.
Fermentation Division	Robert D. Coghill, Chief.
Oil and Protein Division	John C. Cowan, Chief.
Starch and Dextrose Division	Guido E. Hilbert, Chief.

SOUTHERN REGIONAL RESEARCH LABORATORY, NEW ORLEANS, LA.

Director	Daniel F. J. Lynch.
Assistant Director	Howard S. Paine.
Analytical, Physical Chemical, and Physical Division	Turner H. Hopper, Chief.
Chemical Engineering and Development Division	Edward A. Gastrock, Chief.
Cotton Chemical Finishing Division	James D. Dean, Chief.
Cotton Processing Division	Robert J. Cheatham, Chief.
Cotton Fiber Research Division	W. Kyle Ward, Jr., Chief.
Oil, Fat, and Protein Division	Klare S. Markley, Chief.
Sweetpotato Products Division	Paul R. Dawson, Chief.

EASTERN REGIONAL RESEARCH LABORATORY, WYNDMOOR, PA.

Director	Percy A. Wells.
Assistant Director	Rex E. Lothrop.
Analytical and Physical Chemistry Division	Michael J. Copley, Chief.
Biochemical Division	John J. Willaman, Chief.
Carbohydrate Division	Lee T. Smith, Chief.
Chemical Engineering and Development Division	Roderick K. Eskew, Chief.
Hides, Tanning Materials, and Leather Division	Jerome S. Rogers, Acting Chief.
Oil and Fat Division	Waldo C. Ault, Chief.
Protein Division	Richard W. Jackson, Chief.

WESTERN REGIONAL RESEARCH LABORATORY, ALBANY, CALIF.

Director	Theodore L. Swenson.
Biochemical Division	Howard D. Lightbody, Chief.
Commodity Byproducts Division	Louis B. Howard, Chief.
Commodity Processing Division	Robert P. Straka, Acting Chief.
Engineering and Development Division	Wallace B. Van Arsdel, Chief.
Physicochemical and Analytical Division	Charles H. Kunsman, Chief.
Protein Division	George H. Brother, Acting Chief.

PENICILLIN PRODUCTION NOW AN ESTABLISHED INDUSTRY

Last year's report told how the research of the Northern Regional Research Laboratory on penicillin, discovered and proved by British scientists, had helped to get commercial production of this powerful mold-produced antibiotic started. With the improved fermentation process developed by the Northern Regional Laboratory as a basis, production had been undertaken during the year by 17 chemical and pharmaceutical manufacturers.

The growth of the penicillin industry during the past year and a half has been one of the most remarkable developments in the whole war-production program. From approximately 100,000,000 Oxford units per month early in 1943 (about enough to treat 100 serious cases) the production of this invaluable therapeutic agent had increased a thousand-fold to 100,000,000,000 units per month by the middle of 1944. The War Production Board's tentative goal of 200,000,000,000 units per month was expected to be reached by the end of 1944. At the present time penicillin is being used routinely in the front lines of the Allied Armies in Europe as a purely prophylactic agent, with the result that Army doctors are tremendously enthusiastic about the way wounds are healing without infection setting in.

To produce the required quantities of penicillin 21 industrial plants have been, or are being, erected in the United States and Canada, varying in capacity from 1,000,000,000 to 70,000,000,000 units per month. Approximately 80 percent of the total production will result from the application of the submerged or "deep" fermentation method, 15 to 18 percent from surface fermentation, and the remainder from the growth of the mold on bran. However, the trend is definitely toward the submerged-fermentation method, and probably all penicillin will be made by this method within a year or two.

The contributions of the Northern Regional Laboratory to the production of penicillin can be divided into three categories: (1) The development of new and better organisms; (2) the discovery of superior

media and operating conditions for the actual fermentation; and (3) improvement of methods for recovering the penicillin from the broth in a form suitable for clinical use.

All industrial penicillin plants in this country are using particular strains of mold developed in the Peoria Laboratory. For surface fermentations, *Penicillium notatum* NRRL 1249.B21 is used exclusively. This organism, although descended from the original Fleming strain, is about twice as good as that strain as ordinarily encountered. The improvement in its penicillin-producing ability was brought about by a process of single spore selection and cultivation, continued until low-yielding variants had been eliminated and the strain had become somewhat stabilized at the higher level. For the submerged or deep fermentation, *P. notatum* NRRL 832 is the strain used. It is not a descendant of the original Fleming strain, but is one of those found in the extensive culture collection of the Northern Regional Laboratory. It is much more stable than the strain used for surface fermentations and can be readily distinguished by microbiologists familiar with the two strains. Recently a strain of *Penicillium chrysogenum* that gives high yields of penicillin was isolated from a moldy cantaloup. This new organism, NRRL 1951.B25, is markedly superior to both of those now used, and it is predicted that eventually it will be adopted by most of the commercial penicillin producers.

The Bureau has made three reports on the improvement of culture media; one of these was confidential in nature. The most important development was the incorporation in the culture medium of corn-steep liquor, a byproduct of the cornstarch industry. The modified nutrient, which increased penicillin yields 30 to 40 times, is being used by all penicillin producers, with a resulting demand for 12,000,000 pounds of corn-steep liquor for the calendar year 1944. The Bureau also found that lactose (milk sugar) is decidedly superior to any other easily available sugar as an energy source for the mold—at least in so far as penicillin production is concerned. Most penicillin plants now use this sugar exclusively, and this use requires more lactose than do all other uses combined; probably 5,500,000 pounds will be used in 1944 and 7,000,000 pounds in 1945.

The Bureau's contribution to methods for isolating penicillin from the spent culture media was considered so important by the Patent Office that its publication was prohibited by a secrecy order. The improved method is being used in some of the industrial plants.

The processes used in the penicillin industry today are based largely upon the methods of producing this drug developed in the investigations begun by the Northern Regional Research Laboratory in July 1941. The results of this research have been made available in three ways. They have been written up in the form of reports that have been made available to the Committee on Medical Research of the Office of Scientific Research and Development, with which the Bureau has been closely cooperating. These reports, classified as "Restricted," have been distributed by the Committee on Medical Research to all the producers and a few others who had a legitimate interest in the problem. To further aid in making this information available to producers, members of the Northern Regional Laboratory's staff have served in the capacity of consultants, traveling from plant to plant and assisting in the application of the methods developed by

the laboratory. Finally, the penicillin industry has availed itself of the opportunity to send groups of its own research scientists to Peoria to learn the techniques being practiced there. This opportunity has been open to foreign as well as domestic groups, including representatives from various South American countries, England, and China.

To summarize, the Bureau's concentrated research on penicillin since July of 1941 has resulted in: (1) Increasing the yield of penicillin by surface cultures 150-fold—from 2 to 300 Oxford units per milliliter of medium; (2) demonstrating that penicillin can be produced by the more practical method of submerged culture in yields of 150 to 175 units per milliliter and supplying an organism especially adapted to this method; and (3) facilitating the establishment of the new $20,000,000 penicillin industry in time to save the arms and legs and lives of thousands of soldiers and sailors of this and other countries of the Allied Nations in the present world conflict.

ANTIBACTERIAL SUBSTANCES PRODUCED BY BACTERIA GROWN ON ASPARAGUS WASTE

Certain chemical substances synthesized by animals, plants, and micro-organisms have the power to prevent or retard the growth of disease germs or actually to destroy them. They are known as antibiotics. Penicillin is an antibiotic that has attracted much attention within the past 2 years. There are other antibiotics, not so generally known, that are useful as surface applications in treating animal and human diseases caused by pathogenic microbes. Some, like citrinin, are produced by molds; others, like tyrothricin, are produced by bacteria; and still others, like lysozyme, exist naturally in animal and plant tissues or secretions.

The problem of producing antibiotics by culturing micro-organisms has received attention at the Western Regional Research Laboratory as a phase of its investigations on the utilization of vegetable and fruit wastes. The juice pressed from asparagus butts, available in large quantities at asparagus canning plants, has been found to have properties favorable to the propagation of certain micro-organisms, including some that produce antibiotics.

Research in cooperation with several industrial organizations has demonstrated that concentrated asparagus juice is useful as a culture medium for the bacteria that produce tyrothricin. Use of the asparagus-juice culture medium appears to make possible a fourfold to fivefold increase in yields of tyrothricin over those regularly obtained industrially.

An antibiotic that had not been previously isolated and described was prepared by growing another species of bacterium in an asparagus-juice medium. This new antibiotic, which has been named "subtilin" from the species producing it, seems to have several advantages over tyrothricin. Yields per unit of time are much larger, and the period of incubation required before the organism produces maximum yields is much shorter than in the case of the tyrothricin-producing organism. The antibiotic activity per unit weight of partially purified subtilin, as estimated by bioassay with *Staphylococcus aureus*, is considerably greater than that of tyrothricin. The pharmacological properties of subtilin, although not yet extensively investigated, ap-

pear to be such that the clinical use of the product may not be limited to surface applications.

A process has been developed for preparing from asparagus butts a juice concentrate that is suitable for use by the microbiological products industry because it can be stored for a reasonable time before use. It consists of disintegrating the butts in a hammer mill, pressing the mass with a screw press, digesting the juice with naturally occurring enzymes, filtering it through cloth prepared with carefully selected filter aid in a plate-and-frame filter press, and concentrating the filtrate in a vacuum of at least 28 inches to a solids content of 70 to 75 percent. An experimental pack of the concentrate, in metal containers, was prepared by an asparagus-canning plant, and the product was made available to the microbiological products industry for experimental use and further evaluation. Requests for many tons of the asparagus-juice concentrate have been sent to the packer by industrial firms engaged in manufacturing antibiotics.

ANTIBIOTICS TESTED FOR TOXICITY TO ANIMALS

Before antibiotic substances produced by micro-organisms or isolated from plants or animal tissues or secretions can be used safely against pathogenic organisms, their toxicity to animals and probable toxicity to human beings must be known. For this reason, the Pharmacological Research Division started investigations on the physiological effects of citrinin and other antibiotics on small animals. It was first necessary to purify available samples of material. A simple and rapid method was developed for purifying citrinin, after which the toxicity of the pure compound was determined for rats, rabbits, and guinea pigs. The tests showed the necessity of limiting the quantity administered to very small doses. Progress has been made in determining exactly the maximum dosage that can be tolerated and in learning the mechanism of the toxic reactions, rate of excretion, maintenance of the drug's concentration in the blood, and distribution in the tissues. This information is necessary to evaluate citrinin as a potential therapeutic agent.

ALLERGENIC COMPONENT OF CASTOR BEANS SURVIVES COOKING

Recent studies on allergens of agricultural products revealed the nature of hazards confronting those exposed to castor beans in milling operations and in utilizing the press cake from the recovery of castor bean oil. The toxic protein component, ricin, which has disqualified the press cake for edible products, can be rendered virtually harmless by thorough cooking. However, a treacherous hazard was recently identified in the form of another protein component, CB–1A, which survives the cooking and retains extraordinary capacity to first induce sensitiveness to this component and then to provoke severe allergic reactions upon subsequent exposure to it, as in dust from the dried bean or the press cake. Both domestic and imported varieties of castor bean are essentially alike in this respect.

Continued research in collaboration with the Office of the Surgeon General, on egg proteins as extraneous allergens of certain highly important vaccines, yielded information of value in maintaining the health and efficiency of this country's armed forces. At present this is restricted to official use.

RUTIN, NEW MEDICINAL AGENT, ISOLATED FROM TOBACCO

In its research on the industrial utilization of tobacco, the Eastern Regional Research Laboratory isolated from flue-cured bright tobacco a substantial quantity of the yellow plant pigment rutin, recently proved to have medicinal value. The method used comprised percolation of the coarsely ground leaf tobacco with ethyl alcohol at room temperature, removal of alcohol by evaporation, extraction of the residue with boiling water, filtration, cooling of filtrate, recovery of material deposited on cooling, and purification of this material by repeated crystallizations from solutions in hot dilute ethyl alcohol. The yields ranged from 0.008 to 0.61 percent, averaging about 0.4 percent for good-quality leaf. The best yields were obtained from leaf of high quality. No rutin was obtained from stems or midribs. Lower yields were obtained when methyl alcohol was used instead of ethyl alcohol for extraction and recrystallization.

Many samples of cured tobacco were examined at the Eastern Regional Laboratory, but no rutin was obtained from any air-cured type. This substantiates the results of previous investigators which indicated that any rutin in the green tobacco would be oxidized to brown pigments during the air-curing process. Flue curing evidently inactivates the enzymes that catalyze oxidation and is thus responsible for the persistence of rutin in the cured product. Moreover, the bright tobacco for which the flue-curing process is used probably contains more rutin originally than other tobaccos.

An unsuccessful attempt was made to extract rutin from green Pennsylvania cigar filler tobacco. If it were possible to extract rutin from green tobaccos, unsalable leaf could be harvested for use as a source of rutin. Whether the failure was due to faulty technique or to the fact that no rutin exists in green tobacco of this type is not yet known. Further investigations are contemplated.

The rutin prepared from flue-cured tobacco was supplied to the Medical School of the University of Pennsylvania for clinical testing. Its value in treating cases of increased fragility of blood capillaries, the breaking of which sometimes causes apoplexy in persons with high blood pressure, was confirmed by marked improvement in most of the patients treated. By combining rutin with remedies for high blood pressure, definite improvement can be effected in a shorter time. The chemical properties of rutin and results of the treatments with it were reported by two scientists from the University of Pennsylvania and one from the Eastern Regional Laboratory to the Pennsylvania State Medical Society, which awarded a prize certificate to the three scientists in appreciation of their work.

OIL-SOLUBLE NICOTINE COMPOUNDS DEVELOPED

Heretofore, the use of nicotine and nicotine compounnds as insecticides has been somewhat limited since no suitable oil-soluble, water-insoluble derivative of the alkaloid was known. An oil-soluble, water-insoluble nicotine insecticide would have definite advantages including: (1) Increased efficiency in penetrating the waxy protective coatings of insects, (2) concentration in the oil phase of oil-in-water emulsions, and (3) longer serviceability resulting from decreased removal from plant surfaces by rains and heavy dews.

Continued research by the Eastern Regional Research Laboratory on the nicotinammino-salt type of nicotine compounds, previously reported, has resulted in the preparation of a unique series of compounds that are insoluble in water but soluble in hydrocarbon solvents such as are used in oil sprays. Each of these compounds is a double salt of nicotine and a bivalent metal with certain fatty acids. Since copper, a recognized fungicidal agent, is particularly well suited for the preparation of an oil-soluble nicotine compound, it is possible to prepare a product that possesses fungicidal as well as insecticidal activity. The compounds appear to be sufficiently stable to promise an increased residual toxicity over free nicotine or nicotine sulfate. Preliminary tests by the Bureau of Entomology and Plant Quarantine have shown that these compounds are as toxic as or slightly more toxic than nicotine itself on an equimolecular-weight basis. Several industrial companies have requested samples of these compounds for testing. Although these oil-soluble compounds would be classified under fixed-nicotine type on a chemical basis, they have been found to be effective against *Aphis rumicis*, for which the free-nicotine type of insecticide is commonly used. Commercial production of an oil-soluble copper-nicotine compound may result from the fact that it supplies an insecticide and a fungicide in one package and in one application.

FURTHER ADVANCES MADE IN FOOD DEHYDRATION

The results of the engineering and technological research and of incidental studies on dehydration of food that have a direct bearing on commercial production of dehydrated vegetables and fruits, were published by the Department as Miscellaneous Publication No. 540, entitled "Vegetable and Fruit Dehydration—A Manual for Plant Operators." This manual makes available to actual and prospective commercial plant operators useful information gained through research during the last 3 years at the Western Regional Research Laboratory, as well as the results of collateral investigations and previously existing information pertinent to the subject.

During the past year, the Bureau continued its research on dehydration and on dehydrated foods, in cooperation with the industry and with State and Federal Government agencies, the main purpose being to further improve the palatability and keeping quality of dehydrated vegetables, fruits, and eggs. This general objective involves improvements in processing equipment and technique, in packaging, in the selection and control of storage conditions, and in chemical-testing methods for controlling enzyme inactivation and for determining vitamin retention by dehydrated foods.

Research on procedures for compressing dehydrated foods in order to make the saving in bulk as great as the saving in weight, which had already received some attention in the Bureau's dehydration research program, was broadened and accelerated as the result of a special grant of supplementary funds by the Office of Production, Research, and Development of the War Production Board and carried out in cooperation with that agency. The experiments were confined to the seven most important dehydrated vegetables (potatoes, sweetpotatoes, onions, cabbage, carrots, beets, and rutabagas) and to spray-dried

whole eggs. All except potatoes and eggs could be easily compressed by a relatively simple procedure, which comprised prewarming the dry product, pressing it into 1-pound or 2-pound block with a hydraulic press, and immediately restraining and cooling the compressed block. A package made up of such blocks contained from 50 to 150 percent more net weight of food than one of the same size containing the uncompressed material in bulk. Dehydrated potatoes were compressed successfully in the laboratory by pressing them into blocks while slightly moist and then drying them to the required degree, but no practical means for carrying out this procedure on the commercial scale, without injuring the product, has yet been devised. A similar expedient was used for dehydrated eggs, but the difficulty of drying the compressed blocks is so great that a means of preparing satisfactory blocks directly from the low-moisture powder is still being sought.

Improvements in dehydrator design were made available to the industry. Not only the versatile and simple counterflow tunnel drier, but also the more efficient two-stage combination of tunnel and bin driers and a simple and efficient portable cabinet drier suitable for institutional use were analyzed in the light of operating experience and new experimentally acquired knowledge about the drying characteristics of the common vegetables. The resulting designs are more solidly based on exact information than has ever before been possible.

Further improvements in the auxiliary equipment used by the dehydration industry were also devised during the year. A radically new way of constructing and operating steam blanchers was demonstrated on a pilot-plant scale. While development work has not been completed, the indications were that the new blancher offers a possibility of major savings in space requirement, equipment cost, maintenance cost, and steam consumption in blanching vegetables before drying them, which is an essential step in most cases.

The application of sulfur dioxide gas or sulfite solution to cabbage before dehydration, previously practiced by food packers in Canada and England, became common in the United States during the past year. Investigations at the Western Regional Laboratory confirmed the claims that this practice is advantageous. Higher drying temperatures can be used, and retention of color and vitamin C is more satisfactory, when sulfite is used. Because of these advantages, Government purchasing agencies adopted specifications that required the application of sulfite to cabbage in proportions of 750 to 1,500 parts per million of dehydrated cabbage. In order to learn how to meet this requirement, intensive studies were made in the Bureau's dehydration pilot plant and in commercial plants. A practical and effective method of applying sulfite solution during the blanching operation was devised. It entails a minimum of disturbance in the regular plant operations. This method has been used in the commercial production of several million pounds of improved dehydrated cabbage.

Since no easy method for determining the sulfite content of treated cabbage was available, either for plant control or for inspection, a simplified analytical procedure for sulfur dioxide in dehydrated foods was developed. It is being used as the official method by Government inspectors.

The sulfiting studies were extended to determine if there is any advantage in applying sulfur dioxide gas or sulfite solution to other

vegetables, such as potatoes, sweetpotatoes, carrots, onions, and tomatoes. Experiments are in progress to determine the optimum concentration of sulfur dioxide in the dried vegetable, and the best method of application.

The results of storage tests on vegetables, dried under similar conditions to different moisture levels and stored at different temperatures in air, in oxygen-free nitrogen, and in nitrogen containing low proportions of oxygen, threw light on the question as to what factors are responsible for deterioration during processing and storage. It was clearly demonstrated that the keeping quality of carrots and cabbage can be greatly improved by further reduction of moisture content, and that this factor outweighs the influence of the surrounding atmosphere. On the basis of information gained from these tests, a procedure was devised for learning in a relatively short time the probable shelf life of vegetables dehydrated to definite moisture levels and stored at definite temperatures.

The conditions under which potatoes and onions have been stored prior to dehydration were found to influence the drying characteristics of these vegetables and the quality of the dried products. Much of the discoloration and low quality of some dehydrated potatoes was traced to an increase in sugar content of the raw potatoes caused by low-temperature storage. It was shown that the bad effects of cold storage can be overcome in some measure by holding the potatoes at or above room temperature for about two weeks before processing.

Excessive blanching was found to be responsible for the poor quality of some of the dehydrated potatoes produced last year. The dried potato strips showed a marked tendency to lose shape and become mushy during rehydration and cooking if the raw potatoes had been blanched long enough to completely inactivate the peroxidase enzyme, as specified for Government purchases. Storage tests proved that blanching for a shorter time, which permitted some residual peroxidase, did not adversely affect keeping quality. To allow for such conditions, an entirely new peroxidase test was developed; it permits the application of a tolerance and overcomes much of the subjective character of the old test.

A number of reasonably good fruit powders were prepared in spray-drying experiments on a laboratory scale. The successful production of whole-orange powder was the most significant achievement. The juices of some fruits were spray dried, after addition of sugar and pectin, to produce jelly powders. These can be converted to jelly by heating for a short time in water. Several substances were found to be effective as drying aids for facilitating the desiccation of fruit juices to free-flowing powders. A large pilot-plant spray drier of unique construction was designed and installed at the Western Regional Laboratory for spray-drying experiments on a larger scale.

Pilot-plant experiments yielded further information regarding the best conditions (temperature, humidity, tray loading, etc.) for use in the dehydration of different vegetables, different varieties of the same vegetable, and particular vegetables subjected to different preparatory treatments or different conditions of storage in the raw condition. This information made it possible to suggest ways of overcoming some shortcomings in raw material and producing wholly acceptable products from types of raw material previously thought to be unusable.

QUALITY OF DRIED EGGS IMPROVED THROUGH MICROBIOLOGICAL STUDIES

A 30-fold increase in production of dried whole-egg powder occurred between 1939 and 1943 in order to supply increased quantities of eggs in a convenient form for packaging and transportation under lend-lease arrangements and also, since early in 1942, for American armed forces abroad. By the end of 1942 more than 100 plants were drying eggs, and, as might be expected, some of the operators did not fully realize that high quality depends upon strict sanitation in handling and processing, refrigeration of shell eggs and liquid-egg mix while being held for drying, and use of only clean, high grade, strictly fresh eggs. Many complaints were made that the egg powder did not keep well, that it had an unpleasant odor or flavor, and that it sometimes contained food-poisoning bacteria.

The Bureau of Agricultural and Industrial Chemistry was asked by food-control and food-purchasing agencies of the Government to make microbiological studies on commercial dried eggs to determine their quality before purchase and exportation and to learn where improvements might be made in the product.

Thus far, nearly 3,000 samples of commercial egg powder have been obtained from egg driers throughout the United States and examined for different kinds of micro-organisms by the Microbiology Research Division. The Division wanted to learn how the proportions of microbial species in dried eggs are affected by geographic and seasonal conditions, handling practices, type of drier, and drying and storage conditions. The Government, through the Office of Distribution of the War Food Administration and the Foreign Economic Administration, has made immediate use of the data in several ways. For example, these data helped in evaluating the quality of the egg powder offered, in judging the quality of the shell eggs used, and in determining sanitary conditions in different plants and which plants should receive official approval as sources of dried eggs. They helped also in establishing tentative microbiological standards and in assuring foreign food missions that every effort is being made to improve the quality of dried eggs being produced in the United States.

The results of the microbiological studies were of service to the industry too, particularly as a basis for and guide in continued endeavors to improve the quality of dried eggs, and as an inspiration to compete in the production of egg powder having the highest possible quality. They have convinced the industry that in order to produce an egg powder of low microbial count, high palatability, and ready solubility—one that will more nearly resemble fresh egg—it is necessary to use for drying only clean, high-quality shell eggs and to apply strict sanitary principles in all stages of handling, processing, storing, and distributing.

"VELVA FRUIT" OFFERS COMMERCIAL OUTLET FOR SURPLUS CANTALOUPS AND OTHER FRUITS

"Velva Fruit" is the name of new high-quality frozen-fruit dessert developed by the Western Regional Research Laboratory. It has been recorded in the U. S. Patent Office as a generic name that may be used by any manufacturer for frozen desserts of a particular type

to distinguish them from other frozen desserts. Usually Velva Fruit contains only pure fresh-fruit puree, sugar (enough sugar being added to bring the soluble-solids up to 33 to 37 percent by weight), and 0.6 to 1 percent of gelatin in the form of a 10-percent sol. The milder-flavored fruits require addition of a little citric acid, not over 0.25 percent, to give tartness. One of the specifications in the official record of the name is that Velva Fruit shall not contain artificial flavor or color.

Velva Fruit has the natural flavor and color of the fresh fruit from which it is made, along with a pleasingly soft, smooth texture, essentially the same as that of ice cream. This texture is obtained by freezing the prepared mix in an ice-cream freezer, which incorporates sufficient air into the mass to give an "overrun," or increase in volume, of up to 100 percent. When the desired overrun has been obtained, the temperature of the product is adjusted to between 18° and 25° F. to facilitate drawing.

This new dessert differs from fruit ices and sherbets in having a much higher content of fruit puree and a much greater overrun. Ices and sherbets usually contain not more than 20 percent of fruit puree or juice by weight, whereas Velva Fruit contains over 50 percent. Sherbets have 25 to 40 percent overrun, while Velva Fruit has 80 to 100 percent. All of the nutritional qualities of the fresh fruit are well preserved in this new food, including a very large proportion of the fugitive vitamin C, which is more abundant in fresh than in cooked fruits.

Superior quality in Velva Fruit depends to a large extent on the selection of fully plant-ripened fruit that will produce a puree having a pronounced, characteristic flavor. The kinds and varieties of fruits found thus far to be most suitable are strawberries, raspberries, dewberries and their hybrids, blackberries, red-fleshed plums, cantaloups, apricots, peaches, and blends of berries with apples or pears.

Cantaloup Velva Fruit is one of the most promising of the many kinds tried, and one of the most interesting because it provides a means of utilizing a large proportion of the surplus cantaloups that are left in the field each year, either because the fruit matures too rapidly to be absorbed by the fresh-fruit market or because it is blemished, misshapen, or off-grade in size. It is estimated that around 20,000 tons of cantaloups have been wasted each year in only one of the growing areas in California because heretofore no use could be made of the melons unsuited for the fresh-fruit market.

In preparing the fruit puree a substantial proportion of finely divided fruit solids should be included. A clear juice or thin puree lacks the "body" provided by fruit solids, which are essential to good quality. However, the fruit solids must be finely divided to provide a smooth texture in the dessert. If air is incorporated while the puree is being prepared the vitamin content, and in many kinds of fruit the flavor and color, will be adversely affected.

In preparing purees to be quick-frozen for subsequent use in Velva Fruit manufacture, the flavor is best retained, as a rule, if heat treatment of the fruit or puree is avoided. It is desirable therefore to quick-freeze the puree promptly and, at the time it is to be made into Velva Fruit, to defrost it by placing the closed container in a cool

place, so as to prevent deterioration from oxidative changes and microbial growth. Apricots and plums are exceptions to the rule, in that the flavor of apricots is improved, and the quality of plums is stabilized without impairing their fresh flavor, by flash-heating to 190° to 200° F., followed immediately by rapid cooling. Some fruit, like peaches and light-colored sweet cherries, having flesh that turns brown when exposed to air, are put in boiling sugar sirup for 2 to 5 minutes before being reduced to puree.

CITRUS JUICE CONCENTRATES UNDER INVESTIGATION

Citrus fruit juices provide an excellent natural source of vitamin C and are in great demand in Great Britain and other Allied Nations where people normally consume fresh fruit as the source of this vitamin. Because of limited shipping space for fresh fruit and the shortage of tin cans and storage facilities for canned juices, orange juice is concentrated by the vacuum method to one-seventh of its original volume. Approximately 2 million gallons of concentrated orange juice were produced in Florida last year for lend-lease shipment, mainly to Great Britain for nursing and expectant mothers and children under 5 years of age.

At ordinary temperatures the constituents of concentrated orange juice react with each other, causing darkening, loss of flavor, and evolution of carbon dioxide gas, frequently accompanied by bursting of the containers. This reaction, as well as fermentation by yeast in unsterilized concentrate, can be prevented by storage and shipment under refrigeration, but refrigeration is not always available. Other means of prevention, therefore, are being sought.

Through a series of studies at the United States Citrus Products Laboratory in Winter Haven, Fla., on the changes that occur in concentrated orange juice at increasingly high temperatures, it was determined that gas production by enzymic action is improbable. The rate of gas evolution was found to increase at higher temperatures, which indicates ready decomposition of certain juice constituents with loss of carbon dioxide. Analysis of reacting concentrated juice showed almost complete loss of ascorbic acid (vitamin C). Measurable changes were not detected in other constituents of reacting concentrated juice. Reactions occurred, however, with the evolution of carbon dioxide when combinations of juice constituents were brought together in water solution and heated, indicating the possibility that more than one constituent serves as the source of carbon dioxide gas.

Concentrated orange juice is fermented by yeast at ordinary temperatures, and such fermentation also results in the evolution of carbon dioxide gas. Several different kinds of yeast have been isolated from cans of fermenting juice, and their physiological, morphological, and cultural characteristics are being studied. The amount of time required for heat at different temperatures to kill the cells of representative cultures was determined in single-strength and concentrated juices. These results may be used in establishing pasteurization temperatures for concentrated orange juice.

GRAPEFRUIT PECTIN-POMACE COMMERCIALIZED

The rapid expansion of the marmalade, jam, and jelly industry in the United States and other Allied Nations and the use of pectin

in pharmaceutical products as an emulsifying agent have resulted in domestic and export demands for powdered pectin in excess of the capacity of the pectin industry. The manufacture of powdered pectin requires elaborate and specialized equipment. To help relieve the shortage of pectin, a process was developed at the United States Citrus Products Laboratory, Winter Haven, Fla., for the production of grapefruit pectin-pomace from waste grapefruit peel at canning plants. The process consists of washing and grinding the peel, leaching out the water-soluble constituents, pressing out excess liquid, and drying. Pectic enzymes are inactivated in the ground peel by using hot water for the first leaching. Cold water is used for subsequent leachings. A distinct advantage of this method is that critical materials are not required and that most of the necessary equipment is generally available in citrus-processing plants. Two grapefruit canners have utilized the process and produced grapefruit pectin-pomace commercially. With technical advice and assistance from the laboratory personnel, numerous improvements have been made in the original process; these have resulted in a higher quality of product, easier plant operation, and reduced labor requirements.

TABLE SIRUP PREPARED FROM APPLE JUICE

The Eastern Regional Research Laboratory has developed a very palatable sirup from apple juice for food uses, such as table sirup. This is a bland sirup; that is, it does not have the tartness and flavor of apples. It differs from sirup previously developed by the same laboratory in not having the slightly bitter aftertaste that results from the presence of calcium salts. The process of preparing this new type of sirup from apple juice comprises filtration of the juice, passage through a bed of anion-exchange material that absorbs the malic acid, liming, filtration to remove precipitated calcium pectate, acidification, and concentration under vacuum. Some arsenical spray residue is removed in this process, but if more than a trace of lead arsenate is in the juice successive treatments with cation- and anion-exchange materials are required.

A concentrated apple juice that retains the flavor of the fresh apples has been prepared on a pilot-plant scale. It is made by blending ordinary concentrated apple juice with the concentrated apple-flavoring substances obtained by condensing the more volatile portion of apple juice at a low temperature and fractionally distillling the condensate. A 100-fold concentration of the flavoring substances has been obtained in a continuous process. When the full-flavored, concentrated juice is diluted with about six parts of water it is practically indistinguishable from fresh sweet cider except for its lighter color.

The bland apple sirup previously developed by the Eastern Regional Laboratory has assumed commercial importance during the past 2 years and has been accepted as a humectant by the tobacco industry. At least four manufacturers used it in their formulas for cigarette tobacco, and several of the larger companies will be definitely interested in it as soon as the supply can be enlarged to meet their requirements. In addition to keeping tobacco moist, apple sirup helps to develop the aromatic fragrance of Burley pipe-smoking tobacco.

TARTRATES RECOVERED FROM GRAPE WASTES BY NEW PROCESS

Further studies on the recovery of tartaric acid salts from grape pomace and brandy distillery residue led to the development of a new process substantially simpler than the one described in last year's report. The new process eliminates the need for cation-exchange materials and thus requires only about half the plant equipment of the former process. Labor requirements are correspondingly reduced.

The salts of tartaric acid are recovered by passing the well settled or otherwise clarified solution of grape waste through beds of anion-exchange material previously loaded with chloride ions. Tartrate ions from the solution efficiently replace chloride ions in the exchanger. Later a strong solution of sodium chloride is used to remove the tartrate in a concentration of at least 10 times that of the grape-waste solution and at the same time to regenerate the exchanger for the succeeding cycle. The tartrate solution is decolorized and treated with calcium chloride under controlled conditions to precipitate calcium tartrate, from which tartaric acid may be recovered by treatment with an equivalent quantity of sulfuric acid.

Cooperative experiments on a pilot-plant scale, in which about 5 tons of calcium tartrate were produced, have demonstrated the advantages of the ion-exchange process as far as yield and quality of product are concerned. Chemicals required for regeneration of the exchanger and for precipitation of calcium tartrate are not costly. Labor costs vary with character of equipment and magnitude of the operation. Continued contact with the turbid grape-waste solutions results in deterioration of the exchange material through adsorption of substances not removed in the usual regeneration process. Means for removal of these have now been developed, and the estimated useful life of anion-exchange materials is 500 cycles. A total recovery of about 1,600 pounds of tartaric acid per cubic foot of anion exchanger would be expected on this basis.

The United States requires about 15,000,000 pounds of tartaric acid annually for making baking powder, pharmaceuticals, and beverages, and for important industrial uses. It is made principally from imported argols, tartar, and wine lees.

NIGHTSHADE BERRIES REMOVED FROM CANNING PEAS BY NOVEL PROCESS

Nightshade is a troublesome weed in the commercial pea-growing areas of Oregon and Washington, where about one-fourth of the Nation's supply of canned peas is packed. Its immature berries, which closely resemble peas, sometimes contaminate mechanically harvested and shelled peas because they are not removed by the usual cleaning equipment. Removal of the berries on inspection belts is so difficult as to be impractical at times, and it becomes necessary to reject heavily contaminated lots or to avoid cutting portions of fields badly infested with nightshade weeds. Some large canners in Washington estimated that rejections represented from 3 to 10 percent of their total pea crop in 1941. Applied to all the peas grown in Washington and Oregon that year this proportion would mean a waste of from 4 to 14 million pounds of shelled peas. In order to prevent this loss of food and profits, a flotation process for removing

nightshade berries and other foreign material from mechanically shelled green peas was worked out in the field laboratory at Pullman, Wash., in cooperation with the Washington Agricultural Experiment Station and pea canners. Successful pilot-plant trials of the process were made during 1943, and several canning plants expected to adapt the process to commercial use in 1944.

The new process, for which a patent application is pending, is based on the difference in the wettability of shelled peas and nightshade berries. This difference is enhanced by applying a very small quantity of mineral oil in a preliminary treatment, after which the peas are fed mechanically into the top of a tank containing a foaming emulsion. With properly adjusted conditions as regards quantity of oil and foaming agent used, the nightshade berries, other weed seeds, and debris float and flow out of the tank, while the peas sink and emerge from the bottom. Most of the oil is removed by rinsing, and all but a minute trace is removed in the usual blanching operation before canning.

LEAF MEALS FROM VEGETABLE WASTES VALUABLE AS FEED

During the past year the Eastern Regional Research Laboratory has gathered data on the quantities of waste from commercially grown fresh vegetables in the fields, at shipping points, and at various kinds of processing plants, especially those that are promising as sources of high-protein, high-vitamin feeds, and has prepared this and other pertinent information for publication. The wastes that accumulate at shipping points where the fresh vegetables are graded and packed for market and at vineries and processing plants, were considered to be available for processing into feedstuffs or other products. The estimate for total waste available annually from 9 vegetables was 2,626,000 tons. The largest waste item, 1,751,000 tons, represented pea vines and pods; the second largest, 413,000 tons, tomato culls and trimmings; the third largest, 268,000 tons, lima bean vines and pods. The estimates for annual wastes from other vegetables, in descending order, were: Carrot tops, 57,000 tons; beet tops, 42,000 tons; spinach trimmings, 34,000 tons; cabbage trimmings, 33,000 tons; broccoli trimmings, 11,000 tons; and cauliflower trimmings, 10,000 tons.

The Eastern Regional Laboratory prepared substantial quantities of leaf meals from certain vegetable wastes by drying and screening. Chopped pea vines were easily dehydrated in a rotary forage drier with air at a temperature of 500° F. Other vegetable wastes, with the possible exception of carrot tops, pack too closely to permit dehydration in the common type of forage drier. The process used comprised flash-drying with air at about 240° F., which caused the leaves to become dry and brittle while the stems still remained moist and tough, followed by tumbling the material with stones in a rotary screen to break up and sift out the dried leaves. The stems, which have very little feeding value, were rejected. The yields of leaf meal, as percent by weight on the fresh waste, were as follows: Beet, 6.8; broccoli, 7.0; lima bean, 23.0; turnip, 6.5; carrot, 11.0; and pea vine (from viner) 15 to 19.

The first group of cooperative feeding tests on vegetable leaf meals were completed by the Delaware Agricultural Experiment Station.

Fourteen hundred chicks, divided into 7 groups of 200 each, were fed for 14 weeks on a diet containing 8 percent of leaf meal made from a single plant (alfalfa, pea vine, lima bean, broccoli, turnip, or carrot) and a diet that was similar except that it lacked leaf meal and contained proportionately more ground yellow corn and meat scrap. Addition of leaf meal to the diet was beneficial in all cases. Judged by relative rates of growth, the chicks thrived as well on carrot, lima bean, and turnip leaf meals as on alfalfa meal; they thrived even better on broccoli leaf meal because of its higher carotene content; but they did not grow as rapidly on pea vine meal as on alfalfa meal. Detailed results of the tests are reported in Delaware Agricultural Experiment Station Bulletin No. 247.

SWEETPOTATO SILAGE GOOD WINTER FEED IN SOUTH

Investigations of the Agricultural Chemical Research Division in cooperation with the North Carolina Agricultural Experiment Station have shown that excellent silage can be made from sweetpotato vines, or a mixture of vines and cull or surplus tubers. Conservation of this material by ensiling is of particular importance in meeting increased meat and dairy quotas for wartime needs, since thousands of tons of sweetpotato vines are wasted yearly in southern growing areas, where supplies of locally grown winter feed are inadequate to meet even the normal need for livestock.

Feeding tests with dairy cattle, covering a 3-year period and using silage put up in lots of 8 to 14 tons, have shown that silage made from sweetpotato vines or from a mixture of vines and tubers, is equivalent to corn silage in feeding value in a hay-and-grain ration. The maintenance of body weight and milk and fat production of the animals while fed sweetpotato silage was equal to that observed when they were fed corn silage. Also, the sweetpotato-vine silage was rich in carotene (pro-vitamin A), appeared to be highly palatable, and was eaten with practically no waste.

Bacteriological examinations of barreled lots of silage during the curing period showed that the predominating micro-organisms were the *Aerobacter* group of bacteria, the acid-forming bacteria, and the yeasts, which occurred successively during the silage fermentation in the order named. The acid-forming bacteria represented by far the greatest proportion of the total numbers of organisms found. Their activity produced from 1.4 to 1.8 percent of acid, calculated as lactic acid, which gave the ensiled material a pH range of about 3.8 to 3.5. The major portion of the acid fermentation took place within about 2 to 3 weeks after ensiling.

SYNTHETIC RUBBER PROGRAM HELPED BY IMPROVEMENT OF TALLOW EMULSIFIERS

The kind of synthetic rubber being produced in greatest volume (GR–S) results from the copolymerization of butadiene and styrene while they are suspended as minute globules in an emulsion. Since soap is used in preparing the emulsion it is an essential part of the synthetic rubber program. Synthetic rubber plants have obtained inconsistent results in the polymerization process and have suspected that some lots of soap contain substances that retard polymerization.

About 90 million pounds of tallow per year is needed for such soap, and present specifications require that a large proportion be edible tallow, which is ordinarily used in the manufacture of food products.

Since the Eastern Regional Research Laboratory conducts research on animal fats, it undertook an investigation of tallow and tallow soaps as a part of the comprehensive research program of the Rubber Reserve Company, in which a number of universities and several rubber companies and soap manufacturers also participated. It prepared pure samples of the saturated, unsaturated, and modified fat acids and the naturally occurring antioxidants that are present in tallow and tallow soap and sent them to various industrial collaborators for testing individually as to their effect on the polymerization process. It also determined the minor constituents of various tallows and tallow soaps after improving available methods and adapting them to the purpose. Small amounts of linoleic, linolenic, arachidonic, and diene conjugated acids and traces of triene and tetraene conjugated acids were found to comprise the polyunsaturated constituents of tallows and tallow soaps.

Comparison of the analytical data for soaps made from commercial tallows, purified fat acids, and hydrogenated tallow with factory results of polymerization when these same soaps were used as emulsifiers led to the conclusion that the presence of polyunsaturated compounds in the soap is largely responsible for retarded polymerization of GR–S synthetic rubber. It appeared that the more highly unsaturated the fat acid, the greater was its retarding effect. Linolenic acid had about three times the retarding effect of linoleic acid. Oleic acid had no adverse effect; on the contrary, it gave the soaps desirable properties.

Mild selective hydrogenation of tallows before they are used for the preparation of soap was suggested as the best remedy for the difficulties experienced with tallow soap as an emulsifying agent in the polymerization step of synthetic rubber manufacture. If this practice is followed, it is expected, from laboratory results, to lead to improved control of the polymerization step in the manufacture of synthetic rubber, elimination of the present necessity for using edible tallow in soap manufacture, and a 10- to 20-percent increase in the rate of polymerization. It is highly essential to the production of tires that the synthetic rubber used be of the highest possible uniformity. The use of hydrogenated tallow soaps will greatly aid in obtaining the desired uniformity.

MORE LEARNED ABOUT RECOVERY OF RUBBER FROM DOMESTIC PLANTS

During the past fiscal year the Eastern and Southern Regional Research Laboratories, cooperating with other bureaus of the Department in the Emergency Rubber Project, continued their investigations on the recovery of rubber from kok-saghyz, cryptostegia, guayule, and goldenrod. Experimental work to obtain pilot-plant data on the design of factories for the recovery of rubber from guayule was transferred to the new research laboratory and pilot plant erected at Salinas, Calif.

Kok-saghyz.—A simple, practical process was developed for recovering rubber in good quality and good yield from either fresh or dried kok-saghyz roots. A pilot plant for carrying out this process

was designed and built, and about 4,000 pounds of kok-saghyz rubber was produced.

Standard physical tests in the Eastern Regional Laboratory and in the laboratory of a large rubber company showed kok-saghyz rubber to be of very good quality—intermediate between guayule and hevea. About 3,000 pounds of the pilot-plant rubber were to be fabricated into all-kok-saghyz tires by two large rubber companies. These tires, ranging in size from 9.00–20, 10-ply truck tires to 6.00–16, 4-ply, passenger-car tires, were to be subjected to exhaustive laboratory and road tests.

On the basis of pilot-plant operations, it is estimated that a factory costing $1,880,000 and operating 300 days per year would extract an average of 10 long tons of kok-saghyz rubber per day, and would serve a planting area of 39,800 acres net. The cost of extracting the rubber, without credit for byproduct and including amortization and everything except the cost of growing, harvesting, and transporting the roots, would be 11.7 cents per pound. Such a factory could turn out annually a quantity of byproduct sirup, suitable for fermentation to alcohol, containing 6,350,000 pounds of sugars; the value of this byproduct would represent a credit of 2.5 cents per pound of rubber, which would make the net cost of extracting the rubber 9.2 cents per pound.

Assuming a yield of 400 pounds of commercial rubber per acre, which probably could be attained by several years of additional research on breeding and cultivation of high rubber-bearing strains, it is estimated that a smaller factory costing approximately $1,360,000 could turn out 10 tons of rubber per day at a net cost of about 7.4 cents per pound instead of 9.2 cents. The planting area required would be only 16,800 acres net. About 4,000,000 pounds of sugars per year would be produced, and the average credit would be 1.5 cents per pound of rubber.

Since the harvesting seasons cover only one month in the spring and one month in the fall, the necessary root-storage facilities to permit operation of the factory throughout the year are included in all the above figures.

Information accumulated in the course of pilot-plant experiments suggests that further experimentation would make possible material reductions in the estimated costs. Lower cost might result from destruction of the carbohydrates and some other plant constituents by retting the roots. This procedure would cut the cost of the factory in half by eliminating root driers, storage facilities for baled roots, and leaching batteries. The practicability of such a process would have to be established by further pilot-plant experiments.

Cryptostegia.—Because of the extensive plantings of cryptostegia vines in Haiti, where it was planned to recover the high-quality rubber latex by tapping the stems, it was expected that large quantities of leaves from pruning procedures would be available. The research work at the Eastern Regional Laboratory on cryptostegia was therefore directed toward the determination of the nature and distribution of the rubber in the leaves and the development of methods for its isolation.

Microscopic and microanalytical studies showed that about 90 percent of the rubber of mature cryptostegia leaves occurs in globules in

the chlorenchyma. The remainder is in the form of latex contained in the laticiferous ducts which extend into the leaf and follow the veins as they branch into the blade.

It was found that retting with an anaerobic organism, *Clostridium roseum*, would destroy the chlorenchyma cell walls, after which the coagulated protoplasts could be released by mild agitation. The cell rubber could then be recovered by boiling the protoplasts in dilute caustic followed by a creaming operation or by solvent extraction. The latter process is the more feasible. The product is a low-molecular weight rubber. It improves compounding characteristics and building tack when blended with GR-S. When used alone it has relatively low tensile strength.

The recovery of rubber from the leaves of *Cryptostegia grandiflora*, by any means yet devised, does not appear justifiable unless the leaves are available as a waste product from latex-tapping operations and unless there is an acute shortage of rubber, and a sufficient quantity of other natural rubber such as hevea, kok-saghyz, or guayule is not available.

Guayule.—The Eastern Regional Laboratory, in collaboration with the Guayule Rubber Extraction Research Unit at Salinas, Calif., established by the Department under the Emergency Rubber Project, submitted to the Forest Service recommendations of this Bureau for a process of recovering rubber from young guayule plants in January and March of 1944. These recommendations were based upon work done at the Eastern Regional Laboratory between September 1942 and September 1943 and subsequent larger-scale operations at Salinas, Calif., and were intended to serve as a guide in construction of proposed new factories for processing young guayule. The more important features of this process were described in the report for 1943.

As the result of extensive practical tests on the storage of young guayule shrub, carried out cooperatively by the Forest Service at Salinas, Calif., and analytical and technological work by the Eastern Regional Laboratory, it was found that the mechanically defoliated shrub can be baled and kept for 6 or 7 months without significant change in yield or quality of rubber, provided that a moisture content of not less than 20 percent is maintained. This requires storage in a space that can be sealed against the entrance or egress of air. Successful storage for 6 months would permit a guayule rubber recovery plant to operate throughout the year instead of only half of the year.

Forced aeration was found to be essential to successful retting of guayule shrub in bulk. This is an improvement over existing retting processes for guayule, which depend upon natural aeration. The rubber obtained from guayule shrub retted for 21 days under the conditions used by this Bureau had a resin content about 40 percent lower and a tensile strength about 1,200 pounds per square inch higher than had the crude resiniferous rubber obtained from unretted shrub. However, some loss of rubber resulted from the retting process. Retting seems to be advisable only if a sufficiently higher price can be obtained for the higher quality rubber obtained to offset the loss in quantity of rubber from its use.

It was shown that the rubber-hydrocarbon content of guayule worms can be increased by a short pebble-mill scrubbing treatment in dilute ammonia water followed by washing and a similar pebble-mill scrubbing in a dilute solution of ammonium stearate and ammonia.

The physical properties of the rubber were likewise improved by this simple treatment.

Investigations on the drying of guayule rubber with an experimental drier, in which hot air was blown downward through a bed of the rubber worms at high velocity, indicated that an air temperature as high as 200° F. could be used safely. It is believed that this method of drying can be applied in a continuous type of drier, with great saving in labor over the customary method of vaccum drying in batches and with a marked improvement in quality.

Goldenrod.—Investigations at the Southern Regional Research Laboratory on the recovery of rubber from goldenrod were completed with the processing of a substantial part of the crop produced at Waynesboro, Ga., during the 1943 season. The dried plant material was screened, and only the leaf fraction was used. The high resin content of the rubber extract was reduced by a purification step involving precipitation with acetone. More than 800 pounds of rubber was produced, most of which had a resin content below 5 percent; it was converted into usable material by partially compounding in solution and by precuring.

The method of compounding goldenrod rubber in solution consisted of adding part of the sulfur and vulcanizing chemicals to the rubber in benzol solution, thereby obtaining excellent and uniform dispersion. Special equipment was used for removing benzol from the partly compounded mixture by vacuum distillation and for uniformly working and heating the mixture to partially cure the rubber. The precured material was of satisfactory consistency for further compounding and processing on standard rubber mills.

In compounding experiments vulcanizates of both gum and tread stocks were obtained that had tensile strengths up to 3,600 pounds per square inch, and the range for precured batches routinely produced in the pilot plant was from 2,500 to 2,800 pounds per square inch. The tread vulcanizates had a high ultimate elongation and good rebound and resilience, with a fair tensile modulus. Their abrasion resistance was excellent, and their age resistance was good. Goldenrod rubber was comparable to hevea in low hysteresis (heat build-up); indications were that addition of goldenrod rubber to GR–S (up to 30 percent of the mixture) would reduce the excessive hysteresis of the synthetic rubber. In tear resistance and permanent set, goldenrod vulcanizates were inferior to similar hevea vulcanizates.

One of the larger rubber manufacturing companies undertook a factory processing test, based on the encouraging results of laboratory milling and vulcanizing experiments. This comprised the production of plied-fabric bicycle tires, 26 by 2.125 inches in size, by regular manufacturing operations. Over 40 tires were manufactured. A wheel test on 3 of these goldenrod-rubber tires averaged 1,362 miles, as compared to approximately 700 miles for a prewar hevea-and-reclaim tire of similar construction, and approximately 450 miles for current all-reclaim wartime tires.

The critical situation in regard to rubber supplies at the time this project was begun required speedy development of every possible source of natural rubber. The low content of rubber in goldenrod, and the large amount of accompanying resin, made this plant a particularly difficult material to process, but methods were developed for obtaining

high extraction efficiency and for purifying the rubber hydrocarbon to a high degree by simple, practical operations which were carried out successfully on a pilot-plant scale. Despite the unmanageability of the extremely sticky pure rubber initially obtained, practical methods were developed for handling goldenrod rubber and converting it by precuring to an intermediate product suitable for further processing and manufacture into useful rubber articles by the usual rubber-working operations.

COTTON TIRE CORDS IMPROVED BY "DUAL-STRETCH" PROCESS

The work of the Southern Regional Research Laboratory on cotton tire cord, begun in November 1942, has been intensified and broadened in scope during the past fiscal year. The object of this research, namely, the development of improved cotton tire cords, is being approached from two directions; one is experimental selection of the commercially available variety or varieties of cotton most suitable for this use, and the other is the improvement of available cotton through chemical and mechanical treatments.

The initial lot (three groups) of experimental 7.50–20 S–4 military truck tires, mentioned in last year's report, were tested by the United States Army at Camp Normoyle, Tex., and Camp Seeley, Calif. The cords in these tires were of the low-gage (small-diameter) type made from yarns, representing three selected varieties of commercially available cotton, spun by the Southern Regional Laboratory and processed into cord by a commercial tire-cord manufacturer. Detailed results of these tests have not been released by the Army for publication, but it can be stated that the tires made from two of the cotton varieties gave much better performance than any other low-gage cotton-cord tires so far tested by the Army, and that all three groups of tires performed better than the control tires made from standard cotton-cord fabric.

A second lot of 7.50–20 S–4 military truck tires, comprising three groups made from medium-gage cotton cords, were undergoing test by the Army at Camp Normoyle when this report was written. The cords for these tires were also made from yarns spun at the Southern Regional Laboratory.

Cord has been manufactured commercially from the variety of cotton that gave the best results at Camp Normoyle for use in experimental 7.00–20 S–4 truck tires and 6.00–16 S–3 passenger-car tires for testing by the Government Test Fleet. These tires were to be tested against similar tires in both sizes made from standard commercial cotton cords, and against a group of 7.00–20 rayon-cord tires.

Swelling and stretching treatments for cotton tire cords, and for other cotton yarns and cords, have been used in industry. The low-gage cords prepared for tests by the Army were subjected to a wet-stretching treatment. Several treatments of this type have been investigated, and cords showing exceptionally high count-strength products have been produced. As a general rule, an increase in strength obtained in this way is accompanied by a decrease in elongation. This decrease in elongation can become so great that the resulting cord becomes less satisfactory for use in tires. A secondary treatment for stretched cords of this type has been developed to overcome

this difficulty. It makes possible the production of a cord of given elongation while most of the increased strength of highly stretched cords is maintained. The two treatments together constitute a new process which is called the "dual-stretch" process.

In the dual-stretch process for improving tire cord, the original cord, after soaking, is subjected to a tension just short of the breaking point while being dried in hot air. This insures the maximum tensile strength obtainable. The second stage consists of a similar stretching treatment at room temperature in which the tension is carefully adjusted to produce just the desired degree of elongation. In most cases there is a slight loss of tensile strength at this stage, but the final strength is still far above that of the original cord, even in cases where such loss occurs. The influence of this treatment on other characteristics, such as flexing durability and hot breaking strength, is being investigated. Preliminary results indicate that the hot strength is improved. Adhesion of the cord to natural and synthetic rubber does not seem to be affected appreciably by the treatments.

The permanent effect of repeated cycles of temperature changes upon cotton and rayon tire cords has also been investigated. Repeated exposures at low temperatures (−40° F.) showed no significant changes, but very interesting results were obtained after exposure to high temperatures. In the latter case the cords were exposed for 16-hour periods at 265° F. with 8 hours' exposure to standard conditions (a relative humidity of 65 percent and a temperature of 70° F.) between high-temperature exposures and 24 hours' exposure to standard conditions before testing. Both rayon and cotton cords suffered a loss of strength and an increase in elongation under this treatment. After a more severe treatment, heating for 24-hour periods at 265° F., the rayon cord showed a greater decrease in strength and a greater increase in elongation than did the cotton cord. When, however, the cords were tested at this elevated temperature, instead of first being cooled and conditioned, their relative positions were reversed.

In another test, it was found that a single exposure for 16 hours at 280° F. did not produce any great change in the tensile strength and elongation of cotton cord. A separate investigation showed, however, that a significant change in the structure of the cotton, as manifested by viscosity in cuprammonium solution, occurred under these conditions. This is in line with well known observations on other types of cellulosic material that incipient breakdown is evident from the viscosity determination before any change in strength is measurable. Viscosity determinations were made on most of the experimental cords to find out if the cord had been damaged by the treatments.

An investigation was made of the relative adhesion of cotton and rayon tire cords to natural and synthetic rubber both at room temperature and at higher temperatures. In the case of untreated cords cotton had much better adhesion than rayon. It was found that with proper treatment the adhesion of either type of cord could be greatly improved. Promising results were obtained with several new types of adhesives.

At the close of the year investigations on plastic properties of dual-stretched cotton cords were in progress. These included: (1) A study of the behavior of the cords during long-continued uniform loading; (2) measurement of cord relaxation as a result of long-continued,

uniform stretching; and (3) a study of cord behavior under cyclic variable loading. The plastic behavior of cotton cords when subjected to strain at various temperatures is similar to that shown by rubber and other elastic substances. Rayon and mercerized cotton cords have a considerably greater initial plastic flow than wet-stretched cotton cord, but after the initial flow all cords show about the same relaxation rate.

NEW COTTON BANDAGE FABRIC WELCOMED BY HOSPITALS

Large-scale laboratory production and clinical trials of the new elastic and adherent bandage fabric mentioned in last year's report have been continued. Close to 6,000 yards of open-weave cotton cloth (40 inches wide) have been processed and cut into the new bandages. Bandage fabrics have been produced from several different commercially available types of cloth to learn which weave or construction is best suited to the purpose. The texture and elastic properties of the fabrics so produced have been given a laboratory evaluation and one of the fabrics has been given extensive hospital service trials. This particular fabric has all the desirable characteristics of and greater commercial possibilities than any other investigated thus far.

Samples of these new conforming-bandages, which stay in place on extremities and permit movement of bandaged joints, have been used in six hospitals, from which uniformly favorable reports have come. They are giving unusual and very satisfactory results, particularly in bone surgery where they have been proven superior to regular gauze. Thirty dozen bandages have been furnished to the War Department, Office of the Surgeon General, for testing. The United States Naval Hospital at New Orleans has reported:

> It is our opinion after using this product for 6 months that it is superior to regular gauze bandages for special work. It may be sterilized without affecting its elasticity, and has been found particularly desirable in head, knee, arm, or elbow dressing. The greatest amount of these bandages has been used in the orthopedic department. We feel there is a definite need for this product and would encourage the continuance of its development.

Information on the properties and processing of elastic fabrics has been furnished to the leading manufacturers of gauze bandages. A fundamental study of industrial methods used for preparing bandage fabric, particularly kier boiling and bleaching, is in progress. The investigation includes tests on the effects of boiling in different alkalies and of using different bleaching agents. The information will be helpful in adapting the new bandage-making process to commercial use.

WEATHER-RESISTANT FLAMEPROOFING TREATMENTS DEVELOPED FOR COTTON FABRICS

As the result of continued efforts to develop a more effective permanent flameproofing treatment for cotton fabrics, the Southern Regional Research Laboratory has perfected a treatment with antimony oxide, chlorinated hydrocarbons, and a synthetic resin applied as an emulsion. The treated fabric differs only slightly from untreated fabric in appearance, feel, and flexibility and can be subjected to a dozen or more standard launderings without becoming inflammable.

The treatment, which is believed to be commercially feasible, does not weaken the fabric. It definitely increases resistance to the deteriorating effects of outdoor exposure. Test samples, after 6-months' weathering, showed no loss in strength as compared to a normal loss of about 50 percent for the untreated material. Cotton fabric processed by this method is flameproof, but not entirely glowproof. Sometimes, especially when tested after repeated launderings, the charred area glows for several minutes after the flame is removed. Although this fault is minor in some uses, efforts are being made to develop improved fireproofing treatments better suited for garment fabrics. In cooperation with the Office of the Quartermaster General, considerable work has been done in the testing, theoretical elucidation, and improvement of a new commercial flameproofing process, the details of which may not be revealed at this time. This latter treatment has been combined with the former one to give results that are better in some ways than those obtained with either treatment alone.

A method of flameproofing cotton fabrics, involving the use of halogenated organic derivatives of cellulose, has been discovered and is being evaluated. During the past year six applications were prepared for patents covering various flameproofing processes.

INDUSTRIAL UTILIZATION OF SWEETPOTATOES MOVES FORWARD

Establishment of a permanent sweetpotato starch industry, based on the research of this Bureau, seemed to be assured when the United States Sugar Corporation was authorized by the War Production Board to erect a multimillion-dollar sweetpotato starch plant at Clewiston, Fla. Construction was rushed and initial operations were scheduled for the fall of 1944. The plant will have a daily capacity of about 240,000 pounds of finished starch, and an estimated annual production of 50 to 75 million pounds. This development represents a translation to large-volume, streamlined operation of the sweetpotato-starch manufacturing process originally developed in the laboratory, applied on a small commercial scale in the Laurel Starch Factory, and progressively improved through the technical assistance of the Southern Regional Research Laboratory. Plant design, equipment, and the proposed process of the Clewiston plant are based largely on technical data and information obtained in large-scale cooperative tests of improved processing equipment at Laurel in 1941 and subsequently. In maintaining technical control of processing in the new plant, application will undoubtedly be made of the latest findings from continued investigations in the regional laboratory at New Orleans and in the starch factory at Laurel, Miss.

With technical assistance and advice from the Southern Regional Laboratory, the sweetpotato starch plant of the cooperative organization, Sweetpotato Growers, Inc., at Laurel, Miss., continued production of high-quality starch for special wartime requirements. The new L–4–5 high-starch sweetpotato variety developed cooperatively by the Louisiana Agricultural Experiment Station and the Department, which comprised a considerable proportion of the raw material processed in 1943, demonstrated its superior processing quality with high recovery and high quality of starch. It was found feasible to manufacture starch from sweetpotatoes containing a high proportion of Porto Rico sweetpotato culls from an associated plant

dehydrating sweetpotatoes for food use. The improved methods of factory control developed or adapted by the Southern Regional Laboratory greatly facilitated adjustment of processing conditions to the different grades of new material.

Continued investigations on starch byproducts opened up a definite prospect of raising the byproduct credit in sweetpotato-starch manufacture by recovery of 60 percent or more of the sweetpotato protein now wasted in starch factory "fruit water" and by production of feed yeast, *Torula utilis*, from the sugars in the same waste. Use of the protein-recovery process in the small factory at Laurel, Miss., would save daily about a ton of crude protein now wasted and would raise the protein content of sweetpotato pulp, the byproduct feed, from the present 2 to 4 percent to perhaps 16 percent. Similar application of the yeast-production process would yield a ton or more of high-protein, vitamin-rich feed supplement per day. Nearly another ton of yeast per day could be produced from the wasted starch tailings after concentration and conversion of the starch to sugars.

A process was developed on a laboratory scale for the extraction and recovery of high-grade pectin from unlimed sweetpotato pulp in yields as high as 32 pounds per ton of fresh sweetpotatoes. However, integration of this process with other processes providing outlets for the starch and sugars, without requiring lime treatment of the pulp, would be necessary for its economical exploitation.

WHEAT STARCH OBTAINED FROM FLOUR BY NEW PROCESS

The Northern Regional Research Laboratory has developed a new (third) process for separating wheat flour into starch and gluten. It is called the "batter process" because it involves the conversion of flour into an elastic but free-flowing batter by appropriate mixing of a critical amount of water with flour. By tearing apart this batter mechanically in the presence of water, the starch is quickly and almost completely washed out, leaving the gluten suspended in the starch milk in the form of small lumps or curds. The two are separated by flowing the suspension over a vibrating screen; the gluten curds remain on the screen until shaken off, while the starch milk passes through. The starch milk may be used directly for fermentation or for conversion to sirup or crystalline dextrose. However, for the production of prime-quality starch, which is required for making the best grades of sirup and sugar in addition to having important uses requiring no chemical conversion, the starch milk must be subjected to the well-known industrial tabling procedure. The crude gluten passing over the end of the screen contains about 75 percent protein, on the dry basis. A higher grade of gluten, containing up to 95 percent protein, can be prepared by comminuting the wet crude gluten in water to remove most of the residual starch and screening again. Dried at a low temperature the screened material gives an "undevitalized" or natural gum gluten, which is suitable for fortifying low-protein flour for bread making or use in other food products. Drying at higher temperatures, as on a drum drier, yields a product suitable for certain food products, stock feed, and industrial uses.

The batter process has been found applicable to all types of wheat flours or ground wheat except those having a protein content of less than 8 percent. The advantages of the process lie in the speed and

simplicity of operation, the fact that there is no need for chemicals, and the practically complete recovery of the wheat gluten in an undevitalized state. Advantageous use of the batter process can be made in beet-sugar factories and sugar refineries for the production of starch for conversion into sweetening agents. Comparatively little new equipment would need to be installed, because these plants already contain nearly all the equipment necessary for the preparation of sirups from the converted starch liquors. Since beet sugar factories operate seasonally, the production of sirups from starch could be carried out during the off-season; this would keep the plants busy throughout the year. It is for such application that the process is most feasible. Many commercial organizations are testing the process on a pilot-plant scale and, within the past year, a number have used it, with some modifications, on an industrial scale. A beet sugar refinery in the off-season is producing 10 million pounds of wheat sirup monthly from the starch liquors, the byproduct gluten being diverted to another industrial organization for the production of monosodium glutamate, used extensively as a condiment because of its meat-like flavor.

During the past decade soft wheat has been a burdensome surplus crop in the Pacific Northwest; its price has approximated, and, in some years, has even been less than, the Chicago market price of corn. In that region, the production of starch and sirups from wheat appears to be particularly attractive as a permanent industry.

MEANS FOUND FOR CHANGING UNCOOKED STARCHES TO SUGARS

Although raw starches are hydrolyzed to sugars in the digestive processes of many animals, it has not been possible to bring this change about in the laboratory until recently. During the past year the Enzyme Research Laboratory discovered that uncooked wheat flour is readily and almost completely digested by a mixture of enzymic extracts from hog pancreas and the mold *Aspergillus oryzae* grown on bran. There was more than chemical evidence of the change; the gradual break-down of the starch granules was actually observed under the microscope.

The enzymes of *Aspergillus oryzae* in the form of moldy bran, as well as those of malt, are used commercially for hydrolyzing the starch of grains to sugars preparatory to fermentation, but the starchy material must be cooked to get quick results and even then it is unusual for more than 90 percent of the starch to be changed to fermentable sugars. All published data show that the hydrolysis of raw starches to sugars by enzymes is very slow and incomplete.

The discovery that raw starch can be converted to fermentable sugars by enzymes outside of living organisms constitutes an important scientific contribution to the chemistry of starch. Its practical application in fermentation and possibly other industries remains to be developed by further research.

The explanation of the fact that wheat flour is digested readily and almost completely by the mixture of enzymes from hog pancreas and moldy bran is believed to be, in part, that the pancreas and mold extracts contain enzymes that supplement each other, some being able to digest the amylose, and others being able to digest the amylopectin, of the starch. But this is not the complete explanation. An inor-

ganic substance that exists in wheat and can be extracted from the ash of wheat flour also was found to be necessary for rapid hydrolysis. This is calcium chloride. Both calcium and chlorine ions were previously known to have a favorable effect on the enzymic hydrolysis of starch. The complete digestion of pure raw starches requires the addition of traces of calcium chloride along with the mixture of pancreas and moldy bran enzymes, but milled grains probably contain enough calcium and chlorine to make this addition unnecessary.

The conversion of starches to sugars by this method is more complete and many times faster than by the usual enzymic methods. The products of the digestion are glucose and maltose, the former sugar predominating. A small proportion of maltase is present in the extract of moldy bran and is assumed to be responsible for the formation of glucose from maltose. Maltose is the principal product of starch hydrolysis by malt enzymes.

Different starches vary in their susceptibility to hydrolysis by this method. Potato starch is relatively resistant compared to wheat starch or cornstarch, but the size of the starch granules does not seem to be a determining factor in this resistance. A moderately acid reaction, pH 5.2, is best for the digestion of raw starch by the mixed-enzymes method. Temperatures up to 55° C. (131° F.) are permissible when relatively large quantities of enzymes are employed.

GRAIN-TO-GLYCOL-TO-BUTADIENE PROCESS READY FOR INDUSTRIAL USE

The process of making butadiene, the principal intermediate for synthetic rubber manufacture, from butylene glycol obtained by fermentation of dry-milling products of corn or wheat is ready for commercial application.

Last year's report told of the progress that had been made by the Northern Regional Research Laboratory in its special wartime research on fermenting grain mashes to butylene glycol, recovering pure butylene glycol from the fermented liquor, and converting butylene glycol to butadiene. Sufficient work had been done on the three steps of the process to indicate that they could be carried out successfully and that more butadiene could be obtained from a bushel of corn by way of butylene glycol than by way of ethyl alcohol. A system of recovering the glycol from fermented grain mashes had been devised which was expected to overcome the difficulty caused by the high proportion of suspended solids, but this remained to be tried out on a large scale.

The experimental work on this method of making butadiene has been practically completed, and, at the request of the Office of Rubber Director, a manufacturing firm that has supplied much of the distillery equipment used in the United States has prepared a comprehensive report on the equipment that would be required for industrializing this process and has submitted a preliminary design and estimates of construction and operation costs for a plant that could produce 10,000 tons of butadiene per year. As usual, in order to design such a plant, many physical and chemical data based on actual experiments were required. These were available as the result of the laboratory and pilot-plant experiments that had been carried out.

Pilot-plant experiments were made independently by the Northern Regional Research Laboratory and by a large distilling company. While both agencies carried out all steps of the development through the pilot plant, the 1-ton pilot plant of the industrial firm was larger in most respects than that of the Northern Regional Laboratory and this was a distinct advantage in proving the process. Since the conception of the process was entirely a wartime development and there was little background of information upon which to base one of the steps and practically none for the other two, many perplexing problems had to be solved. Those of a fundamental or purely scientific character received special attention from the Northern Regional Laboratory, while those of an engineering and practical nature received attention from both the Northern Regional Laboratory and the industrial firm.

A summarized report on each of the three steps of the process follows:

(1) *Fermentation.*—The demonstration by the Northern Regional Laboratory in 1940 of the possibility of industrializing the fermentation of carbohydrates to 2,3-butylene glycol by the organism *Aerobacter aerogenes* is the basis of the present process. The perfection of the butylene glycol fermentation, which is comparable in its sensitiveness to the butanol process, has been worked out in a period of less than 3 years. Starting with yields of about 10 pounds of butylene glycol per bushel of corn in 1940, yields of 14.5 pounds per bushel have been obtained in the pilot plant and in fermenters having up to 8,000 gallons capacity. Although 14 pounds per bushel is the figure accepted for plant design, continuous operation of a full-scale plant should result in consistently higher yields, since the present fermentation efficiency does not approach theory as closely as is the case with ethyl alcohol or butanol fermentation.

(2) *Glycol recovery.*—Distillation was used by the Northern Regional Laboratory in its first work on the recovery of butylene glycol from dextrose beers, and the concept that some type of distillation technique could be developed as an industrial operating procedure has been generally advanced by this Laboratory. The recovery of butylene glycol has proved to be an exceedingly difficult problem. The following methods have been studied on a pilot-plant scale: Solvent extraction, vaporization by spray drying, atmospheric drying or vacuum-drum drying of fermented mash, distillation of kerosene extract, and steam stripping. Recovery of the residue in a form suitable for use as feed is also involved in each one of these methods. The steam stripping method, developed through pilot-plant scale at the Northern Regional Laboratory, proved entirely practical for continuous operation and was the one considered in the plant design. The cost of steam is low, since the steam can be recycled; glycol recovery is 95 to 97 percent. The steam stripping method has also been investigated on a pilot-plant scale by the distilling company. Examination of the byproduct feed for vitamin content showed that it was equal to high-priced poultry feed suplements in this respect.

(3) *Conversion of glycol to butadiene.*—Experiments on the conversion of butylene glycol to butadiene by esterification and pyrolysis in a 100-pounds-per-day butadiene pilot plant were carried out by the Northern Regional Laboratory. First a continuous esterification proc-

ess was developed on a large laboratory scale; it yielded butylene diacetate (of 99- to 100-percent purity) equivalent to 97 percent of the glycol used; the remaining 3 percent of glycol was represented by a byproduct, methyl ethyl ketone. When this process was tried in the pilot plant of the distilling company, the expectations from laboratory experiments were fulfilled in every respect. The laboratory work indicated an 88-percent conversion of the diacetate to butadiene (of 99-percent purity) and a loss of acetic acid in the recovery process not to exceed 1 percent. These results were realized in the operation of the 100-pounds-per-day butadiene pilot plant at the Northern Regional Laboratory and also in the pilot plant of the distilling company. It is rather unusual in development work for small-scale laboratory results to be so completely substantiated. Equal or better results, therefore, can be expected from full-scale operation.

For the production of butadiene from grain, the butylene glycol process has two distinct advantages over the alcohol process: First, the very high purity of the butadiene made by pyrolysis of ethylene diacetate makes it possible to avoid costly and complicated purification steps; and second, fermentation to a 4-carbon glycol rather than to a 2-carbon alcohol results in a higher over-all yield than by the alcohol process. Assuming a yield of 14 pounds of glycol per bushel of corn, 95-percent glycol recovery, and an 85.4-percent conversion of glycol to butadiene (all of these figures have been consistently obtained in pilot-plant operations), the yield of butadiene per bushel of corn (containing 34 pounds of starch) would be 6.82 pounds. The present yields of butadiene from alcohol are equivalent to about 6.25 pounds of butadiene per bushel of corn.

NEW STARCH COMPOUND USEFUL IN COATINGS AND LAMINATING PLASTICS

The Eastern Regional Research Laboratory in its research on the utilization of carbohydrates has developed methods for the preparation of highly substituted allyl ethers of starch that may find important industrial uses. For the first time allyl starch soluble in organic solvents has been prepared. A direct method of preparation was developed. It comprises the treatment of starch with allyl chloride (made commercially from a byproduct of petroleum distillation) in the presence of concentrated sodium hydroxide and acetone. This method makes possible the commercial production of allyl starch at a relatively low cost.

The most promising use of allyl starch is as a coating material. When applied in solution to a surface of wood, paper, or metal it forms a smooth, glossy coating. When this coating is subjected to heat or long standing, it becomes very resistant to the agents that often damage varnished surfaces. It is no longer soluble in ordinary organic solvents; it is not affected by heat up to 200° C.; and it resists the action of hot oils and moderately concentrated acids and alkalis. A number of catalysts accelerate this polymerization or insolubilization of allyl starch.

Allyl starch compounded on a rubber-working mill with various ingredients used in rubber products, including sulfur and vulcanization accelerators, and subjected to long-continued heating, yields a

hard thermoplastic composition that is highly resistant to organic solvents, oils, acids, alkalis, and heat. Such a plastic can be used as an adhesive for the preparation of laminated materials of good strength and quality from paper, fabrics, and wood veneer.

In order to obtain a better understanding of the mechanism of the polymerization of allyl starch, allyl ethers of simpler carbohydrates and of polyhydroxy compounds have been prepared and used experimentally. These ethers are liquids that can be easily distilled and obtained in the pure state. Being compounds of low molecular weight, and therefore not viscous, they are better than allyl starch for impregnating wood, paper, and textiles and can be polymerized within these materials. Most of them seem to polymerize in the same manner as allyl starch, and some of them may prove to be of practical value. Among the simpler compounds prepared were allyl ethers of sucrose, methyl glucoside, mannitol, sorbitol, inositol, pentaerythritol, ethylene glycol, and glycerol.

CRUDE LACTIC ACID CONVERTED TO PURE DERIVATIVES

Lactic acid can be produced easily by the fermentation of milk sugar and other carbohydrates, but in order to be useful in chemical synthesis it must be purified or be converted into pure derivatives. One of its most important derivatives is methyl lactate, which can be readily transformed into pure lactic acid by treatment with water, into other esters by treatment with various alcohols, and into methyl acrylate (used for making acrylate resin) by acetylation and pyrolysis.

During the past year the Eastern Regional Research Laboratory developed a simple and satisfactory method for preparing pure methyl lactate from crude dilute lactic acid. This is advantageous to the chemical industry because it avoids the cost of first purifying and concentrating the lactic acid. The method comprises passing methanol vapor through an aqueous solution of crude lactic acid heated to about 90° C., condensing the vapors, and fractionally distilling the condensate to recover methyl lactate. It has been used successfully with acidified fermentation liquors and with the residue from the purification of lactic acid by solvent extraction.

Purified lactic acid instead of methyl lactate can be produced by the same method through a slight change in procedure. If the condensate is heated before distillation, the methyl lactate is decomposed into lactic acid and methanol, after which the methanol and water can be removed from the lactic acid by distillation.

INDUSTRIES EAGER TO TRY COCOA-BUTTER AND OLIVE-OIL SUBSTITUTES MADE FROM COTTONSEED AND PEANUT OILS

Last year's report mentioned the successful preparation by the Southern Regional Research Laboratory of a substitute for cocoa butter from cottonseed oil and of a substitute for technical olive oil from peanut oil by processes involving controlled hydrogenation and low-temperature solvent fractionation. The first can replace cocoa butter in confectionery and pharmaceutical products, and the second can replace technical olive oil as a worsted spinning lubricant.

Requests were received from numerous domestic and foreign firms interested in the possible use of these substitutes for samples large enough to permit factory trial in particular products or processes.

Inquiries were also received from industrial firms that were interested in the possibility of producing these substitutes commercially and wanted information on processing details and production costs. To supply large samples and to answer the many requests for cost data and possible commercial yields, pilot-plant experiments will be required. Pilot-plant equipment was designed and ordered.

Pending the installation of the pilot-plant equipment for modifying cottonseed and peanut oils, attention was given to the development of a method for determining various degrees of plasticity in plastic fats, which was needed especially for comparing natural cocoa butter with the substitute therefor. Such a method is equally useful in the study and testing of butter, lard, and plastic shortenings made from oils. Research was also conducted to acquire needed fundamental knowledge on the thermal properties, and especially volume changes from physical or chemical action, of cottonseed and peanut oils, of solid and liquid derivatives of these oils, and of pure synthetic glycerides prepared from the component fatty acids of these oils. The results of this research are given in several papers that were prepared for publication.

GOOD COLD GLUE MADE FROM PEANUT PROTEIN

In order to relieve wartime shortages of gums and other adhesives that are suitable for use in bookbinding and for making gummed tape, gummed paper, and set-up paper boxes, the Southern Regional Research Laboratory undertook the development of such products from cottonseed and peanut meals. Work to date has shown that it is possible to prepare peanut-protein glues suitable for use in the manufacture of gummed tape having relatively good adhesive strength. The dried glue film has good appearance, is less hydroscopic than some gum adhesives, and becomes tacky and sticks tenaciously as soon as it is remoistened and applied to another surface. Unique characteristics of peanut-protein glues, particularly their tackiness and fluidity at room temperature, make them suitable for certain gluing operations for which vegetable proteins have heretofore been considered unsuitable. Since glues made of peanut protein become tacky as soon as moistened and require no heating, they could be used in the paper-box and bookbinding trades with less difficulty than is encountered with certain other types of glue.

GLOBULAR PROTEINS CONVERTED TO FIBROUS FORM

As a result of recent work in the Eastern Regional Research Laboratory methods have been developed for converting so-called globular proteins to the fibrous form in which the polypeptide chains of the protein molecules have substantially the same parallel arrangement as those of the naturally fibrous protein, keratin (found in wool, hair and feathers). This rearrangement in molecular structure yields artificial fibers that are stronger than fibers made from globular proteins. One method, applicable to extruded filaments, comprises heating the globular protein in the presence of water, and stretching it. Alternatively, the conversion is induced without heat through use of certain chemical agents and stretching. Among the globular proteins thus converted, and for which X-ray diffraction patterns characteristic of natural protein fibers have been obtained, are casein, gliadin, zein, soybean protein, peanut protein, hemoglobin, serum albumin, lacto-

globulin, tobacco-seed globulin, ovalbumin, pumpkin-seed globulin, and edestin. The methods used have thus far proved most readily applicable to the simple globulins and albumins, whose physical properties are easily changed by heat or certain chemical reagents. Measurements on casein, lactoglobulin, and ovalbumin filaments have shown that the wet and dry tensile strengths are increased by conversion of the protein to the oriented, fibrous form.

Hardening of artificial protein fibers with quinone and by acetylation has been extensively investigated. The water absorption of casein fibers treated with quinone is about two-thirds as high as that of similar fibers treated with formaldehyde. The protein-quinone complex is quite stable, whereas the reaction of formaldehyde with protein is reversible. In the studies of acetylation it was found that 6 percent of acetyl by weight can be introduced into formaldehyde-hardened fiber without causing deterioration. Fibers of such acetyl content are much superior to the comparable nonacetylated fiber. Water absorption is definitely lowered by acetylation but even more notable is the development of resistance to boiling water solutions. Other hardening treatments more effective than those employing formaldehyde, quinone, or acetylation are being sought.

WATERPROOF GLUE FOR PLYWOOD MADE FROM SOYBEAN MEAL AND PHENOLIC RESIN

As a result of efforts by the Northern Regional Research Laboratory to develop new adhesives from soybeans, the details of a method for preparing a new soybean-modified phenol-formaldehyde adhesive for plywood have been worked out. The glue is prepared by mixing the protein meal with a commercially available or freshly prepared phenolic resin in the intermediate or "A" stage. A high-protein meal is needed, and it can be obtained by removal of the water solubles from extracted soybean meal. One commercial trial has demonstrated that excellent birch and birch-basswood plywood can be fabricated with this glue.

Soybean meal has been used for many years in making adhesives for gluing softwood veneers, but in recent months its use has declined. This decline appears to be due to an emphasis on the production of moistureproof and highly moisture-resistant plywoods. The older soybean adhesives were not highly moisture-resistant; the new adhesive can be made either moistureproof or moisture-resistant by controlling the amount of phenol-formaldehyde used.

The present demand for moistureproof plywood is very high because of the Navy's need for special types of marine construction, and the post-war demand for moisture-resistant plywood is expected to be almost as great. In particular, the fabrication of plywood for outdoor construction where moisture resistance is necessary, such as barns, silos, cement forms, storage bins, and houses, will receive much attention from the industry. Since the new adhesive gives excellent moisture-resistant bonds with both soft and hard woods and its cost is estimated to be much lower than that of other waterproof adhesives, it will probably be accepted by the plywood industry as soon as sufficient plant trials demonstrate its feasibility.

NORELAC, RESIN FROM SOYBEAN OIL, PROGRESSING TOWARD INDUSTRIAL USE

The development by the Northern Regional Research Laboratory of a feasible method for the production of Norelac, a thermoplastic resin, from soybean oil and the demonstration of a number of possible uses for this product have led to its production on a semicommercial basis. In 1943 an industrial firm became sufficiently interested in Norelac to build a pilot plant having a capacity of 1,000 pounds a week. This plant was placed in operation early in 1944, and approximately 15,000 to 20,000 pounds of the resin have been prepared. This small-scale production of Norelac assures thorough evaluation of the material by a large number of industries for many possible uses to an extent that would not be possible at the Laboratory.

Previous work showed that Norelac is useful as a protective coating for wood and steel and as a moistureproof, self-sealing, thermoplastic coating for paper, cellophane, glassine, and other wrapping materials. Preliminary experiments made recently by the Quartermaster Corps have indicated that a Norelac lacquer gives tin cans excellent resistance to corrosion by salt spray. Additional commercial tests are now in progress.

Although the resin is not yet established as a commercial product, two of the steps leading toward its acceptance have been completed; these are laboratory research and pilot-plant development. Its future will depend on careful control of the manufacturing process to obtain the desired properties, additional technical development of uses, and reasonable cost in comparison with competing products.

SOLVENTS STUDIED FOR TUNG OIL EXTRACTION

Further investigations by the Agricultural Chemical Research Division on the possibility of increasing the recovery of oil from domestic tung fruit by the application of solvent extraction showed that the moisture content of tung kernels and of dehulled tung fruits very materially influences ease of preparation and efficiency of the subsequent extraction by solvents. In laboratory extraction tests, maximum efficiencies were obtained with tung kernels containing between 6 and 9 percent of moisture; in pilot-plant studies, in which a continuous counter-current extractor was used, maximum extraction efficiency (99.9 percent) was obtained with dehulled tung fruit containing 7 percent of moisture. Further pilot-plant tests indicated that a clear, liquid tung oil of good quality can be obtained by the use of heptane as the solvent. The relatively high temperature of ground waters in the South would make advantageous the use of heptane instead of hexane, as the solvent, since solvent losses would be materially lower. Varnishes made from the heptane- and hexane-extracted oils, as well as that made from expressed tung oil, appeared to be of high quality; they are being tested for durability near Gainesville, Fla.

GROUND CORNCOBS USED FOR CLEANING AIRPLANE ENGINES

Basing its action on the results of cooperative experimental work by the Northern Regional Research Laboratory, the United States Navy Department has standardized ground corncob (to pass 10-mesh

and be retained on 32-mesh screens. Tyler series) for use as soft-grit material in an air blast for removing carbon from airplane cylinders and pistons. The use of soft grit in an air blast of 80 to 90 pounds pressure is a wartime development; this cleaning method replaces the previously used chemical and mechanical methods of removing carbon and oil residue baked onto high compression-engine parts. Among the first materials employed with the air blast were cracked wheat, corn grits, and clover seeds. Because of the shortage of food materials, the Department of Agriculture, at the suggestion of the Navy, undertook to find suitable substitutes among nonfood materials. Samples of ground crop residues of various kinds were prepared and supplied by the Northern Regional Laboratory for comparative tests. The Navy selected ground corncobs as the most suitable for its purpose. The corncob meal is used repeatedly and lasts from 5 to 10 times as long as the corn grits formerly used; it also has the advantage of polishing the metal parts during the cleaning operation without causing any change in dimensions of the parts. The heavy fraction of ground peanut shells is also suitable for use in air-blast cleaning of metal surfaces. Ground rice hulls, because of their high silica content, are highly abrasive to steel, and cause dulling of polished surfaces. Ground nut shells are reported to be slightly abrasive. Cobs from hybrid seed corn represent the preferred raw material source, since these are dried in the seed houses.

NORESEAL MAY COMPETE SUCCESSFULLY WITH CORK

Publication by the Northern Regional Research Laboratory of technical details relating to the preparation and practical testing of Noreseal, the cork substitute developed from agricultural materials (peanut shells, proteins, and plasticizers) for use in the beverage industry, has aroused wide interest among both bottlers and cork manufacturers. It seems to be generally believed that Noreseal represents the best and most practical cork substitute offered thus far. At least three manufacturers are already contemplating the production of Noreseal; others have indicated their desire to manufacture it when the pilot-plant studies now under way have yielded additional information.

Two pilot-plant investigations are in progress. One pilot plant, having a capacity of 150,000 crown-seal discs per hour, has been built and operated by a trade association in Peoria for testing the method of producing sheet Noreseal. The other, operated by the Northern Regional Laboratory, is developing a method of dispensing Noreseal into individual crowns; this was made possible by the loan of an automatic dispensing machine by an industrial firm. The second investigation is nearing completion. This dispensing process eliminates many of the manufacturing operations required for the preparation of the cork-composition disc. It can be made entirely automatic and is capable of yielding a product of uniform quality. Preliminary cost estimates indicate that Noreseal dispensed directly into crowns may survive competitively as a post-war product.

TURPENTINE DERIVATIVES USEFUL FOR SYNTHETIC RUBBER

The report for 1943 stated that samples of myrcene made by pyrolysis of beta-pinene, isolated from turpentine, were supplied to sev-

eral commercial firms for use in experiments to determine its value for making synthetic rubber. One firm reported that myrcene proved to be a very useful addition to rubber-making materials because its polymerization product increased the tackiness or adhesive property of synthetic rubber in dry form, which is deficient in synthetic rubber of the usual type. This firm also expressed a belief that myrcene might be used as an intermediate for synthesizing other chemical products. It was producing myrcene on a small pilot-plant scale and expected to increase production later.

Improvements were made in laboratory methods of producing myrcene and isoprene from turpentine and in equipment for purifying these and similar products by fractional distillation under vacuum. A patent for a fractionating column and scrubbing tower was granted during the year. By a special pyrolytic method, yields of isoprene above 65 percent of theory were obtained from dipentene, which can be derived from turpentine. Improved techniques were developed for experimental polymerization of myrcene and isoprene to synthetic rubber. Small-scale pilot-plant equipment was being constructed at the Naval Stores Station for the production and purification of beta-pinene, myrcene, and dipentene from turpentine.

NAVAL STORES INDUSTRY USES BUREAU'S GUM-CLEANING PROCESS

During the naval stores season ending March 31, 1944, about 40,000,000 pounds of high-grade rosin and 1,500,000 gallons of turpentine were made from pine gum cleaned by a process developed by the Naval Stores Research Division and covered by U. S. Patent No. 2,254,785, the use of which has been granted to seven commercial firms by license from the Secretary of Agriculture. One commercial firm was licensed to use U. S. Patent No. 2,295,235 covering an improved process for producing rosin, which was also developed by the Naval Stores Research Division.

PINE GUM NOT DAMAGED BY CHEMICAL STIMULATION OF TREES

Tests on pine gum obtained by the United States Forest Service in experiments designed to increase the secretion of oleoresin or gum by the application of a chemical substance to the fresh-cut streaks on southern pine trees demonstrated that rosin and turpentine of good quality can be made from such gum by processes developed by the Naval Stores Research Division of this Bureau. This finding has helped to convince gum producers that it is safe to use chemical stimulants in efforts to attain the production goal for rosin and turpentine.

NEW DOMESTIC SOURCES OF TANNINS EVALUATED

Tannins from barks, woods, leaves, roots, and fruits are essential for making vegetable-tanned leathers. Heretofore, this country has depended on foreign sources for about two-thirds of its vegetable tanning materials. War has curtailed importation of foreign supplies and seriously reduced and threatened to practically stop heavy leather production. It is therefore highly important that the availability and relative value of new and undeveloped domestic tannins be determined.

Several materials have been under investigation at the Eastern Regional Research Laboratory to determine their suitability as sources of tannin.

Canaigre.—Field studies on canaigre (*Rumex hymenosepalus* Torr.) as a tannin crop were continued in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering. From experimental plantings in Texas and New Mexico, and wild and cultivated stands in Arizona, nearly 16,000 pounds of roots were harvested in 1943. In field drying tests about 10,000 pounds of fresh roots, containing about 70 percent of moisture, were successfully shredded and air-dried on hard-surface asphalt, giving a product that could be shipped or stored without spoilage.

The tannin content of canaigre varies with strain of plant and with soil and climatic conditions. Wild canaigre roots secured near Las Cruces, N. Mex., and planted at Winter Haven and Lubbock, Tex., and at State College, N. Mex., have produced five generations of progeny. The average tannin contents of the progeny for the 5 years at the three locations were, respectively, 26.0, 21.8, and 21.2 percent, on a moisture-free basis. Selection and propagation of strains from individual hills of canaigre are worthwhile. One selection at Lubbock, Tex., over a period of 5 years gave a calculated average yield of 12.54 tons of fresh roots per acre, with an average tannin content of 23.3 percent (moisture-free basis). Two selections at Winter Haven, Tex., during the same period yielded an average of 12.33 tons and had an average tannin content of 24.1 percent (moisture-free basis). These experimental yields are higher than those obtained in run-of-field tests, but the tannin contents are about the same.

Canaigre roots contain, in addition to tannin, starch and sugars, both of which may be of economic value. The former interferes with the easy extraction of tannin, and the latter, when extracted with the tannin, are responsible for the production of low-purity tanning extracts. A bulk sample of canaigre roots has been found to contain, on a moisture-free basis, 2.98 percent of free reducing sugars calculated as dextrose, 15.69 percent of disaccharide identified as sucrose, and 25.19 percent starch.

Progress has been made in the laboratory processing of canaigre for the production of extracts suitable for tanning heavy leather. Methods for removal of starch and sugars and their conversion into valuable coproducts are being studied. Use of finely powdered roots has been found to facilitate hydrolysis of the starch. A bacterium has been isolated from canaigre roots which is effective in fermenting canaigre sugars in the presence of tannin without damage to the latter. A tanning extract has been prepared containing 51.9 percent tannin and having a purity (soluble-solids basis) of 65.6.

Scrub oak bark.—About 20 species of scrub oaks grow in Florida and neighboring States, and it is reported that there are about 5,000 square miles of scrub oak forest in Florida. The three most important of these oaks are Turkey oak (*Quercus laevis* Walt.), Bluejack oak (*Quercus cinerea* Michx.), and Blackjack oak (*Quercus marilandica* Muench.). The tannin content of scrub oak barks is reported as ranging from 9 to 12.5 percent, but some samples have been found to contain as much as 16 percent. From a sample of Turkey oak bark from Gainesville, Fla., which contained 10 percent tannin, a

powdered tanning extract has been made in the laboratory; it contained 61.2 percent tannin and had a purity of 63.7. A small-scale tanning test, using this extract for making heavy leather, gave good results. Cooperative tests on a pilot-plant scale are now being planned to determine the feasibility of using scrub oak bark for the manufacture of tanning extract and the extract for tanning heavy leather.

Sumac.—Studies conducted in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering over a number of years have shown that the tannin content of cultivated sumac plants increases with age for the first 3 years of their life. Data for older plants have not yet been obtained. Tannin content was highest in midsummer; it decreased moderately during the fall months.

Young plants cannot be cut profitably more than once a year and should not be cut during the first year. Hereditary factors influence tannin content, indicating that it should be possible to locate desirable strains of sumac that are high in tannin and suitable for propagation.

White sumac (*Rhus glabra*) gathered in eastern Iowa was used in a commercial tanning test and, when dried and handled properly, produced excellent sheepskin leather. Two carloads of sumac were shipped from Iowa to tanning-extract manufacturers in 1943 and similar shipments were planned for 1944.

Western hemlock bark.—Studies on the utilization of Western hemlock bark from floated logs were continued by the Eastern and Western Regional Research Laboratories in cooperation with industrial firms. Laboratory-prepared powdered extracts were made from both fresh water- and salt water-floated barks. That made from fresh water-floated bark was the better of the two, but neither could be considered a high-quality extract. Small-scale tanning tests demonstrated that these extracts could be blended with standard tanning extracts, but their addition did not improve the blends or the leathers produced. The use of a commercial continuous hydraulic press for removing excessive water and some salt from salt water-floated bark was studied at the Western Regional Research Laboratory. After being crushed, the bark was leached rapidly, and the leach liquor was filtered, bisulfited, and evaporated to dryness. The dry powdered extract contained over 66 percent tannin. The leaching efficiency, however, was low, and the tanning properties of the extract were not equal to those of commercial tanning extracts. The economic aspects of the utilization of salt water-floated bark as a source of tannin are not favorable.

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